AD-767 626

A DESIGN FOR A HYDROSTATIC PRESSURE CHAMBER FOR CALIBRATING PIEZOELECTRIC PRESSURE TRANSDUCERS

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May 1970

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TECHNICAL NOTE No. 20

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SUMMARY

The measurement of the intensity and duration of underwater shock waves uses piezoelectric transducers permanently sealed to one end of a coaxial cable. A hydrostatic pressure chamber with a fast pressure release for the calibration of these transducers is described.

The chamber has been designed to operate at pressures up to 10.4 MN/m^2. Pressure is obtained from a built in manual hydraulic screw pump and the pressure is released by a specially designed quick acting valve.

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Reference: WAC/208/03

1. INTRODUCTION

The currently preferred technique for the measurement of the pressure/time characteristics of an underwater explosion uses a piezoelectric transducer permanently sealed to a coaxial cable (Fig. 1). These transducers are subjected to very high pressures and the rate of change of pressure is also very great. In use, the pressure rises to a peak value, which may vary from experiment to experiment from 2 to 100 MN/m^2, in about 12 μs and this pressure will decay exponentially with a time constant of about 200 μs. A critical part of this recording is the steep front and the method of calibration must take this into account.

The method chosen to calibrate the transducers was in the reverse order to which they are subjected, that is to hold the transducer in a known constant hydrostatic pressure and to release the pressure as quickly as possible to induce a shock condition, whilst recording from an oscilloscope trace the behaviour of the transducer.

The cable to which the transducer is attached is not regular in diameter having a groove running along the outside of the cable in which the maker's name is embossed. This gave difficulty in the prototype cable clamp to effect a satisfactory pressure seal.

The quick release valve is a development from two similar valves first tried in the prototype. A copy of the oscilloscope trace showing the release time from 6.9 MN/m^2 down to zero (2 ms approx.) is shown in Fig. 2.

2. DESCRIPTION OF DEVICE

The hydrostatic pressure chamber (Fig. 1) consists of six main parts:

(1) Pressure chamber

(2) Screw pump

(3) Cable seal and clamp

(4) Reservoir

(5) Pressure gauge system

(6) Pressure release valve

The hydraulic fluid used is a mixture of equal parts of "Girling" crimson brake fluid and water.

/The .....

The cable of the transducer is sealed against the hydraulic pressure by the split rubber washer (Fig. 1(a)) and is prevented from being extruded through the seal by the jaws of the serrated tapered collet (Fig. 1(b)), the cable being in tension between the rubber seal and the collet. The assembled cable seal and clamp is retained in the pressure chamber by the large knurled nut (Fig. 1(c)).

Pressure is obtained from the forward travel of the piston (Fig. 1(d)) by rotating the capstan clockwise. Reversal of the piston direction will draw fluid through the non-return valve in the bottom of the reservoir.

Pressure is read from the working pressure gauge nearest the pressure chamber. The pressure gauge farthest from the pressure chamber is of test standard and is used to calibrate the working gauge. The test gauge can be isolated by closing the valve between the two gauges.

Each gauge is protected against the sudden loss of pressure by a pressure bleed device at the base of each gauge (Fig. 1(e)).

Pressure is released by pressing in the button (Fig. 1(f)) at the end of the release valve; the rate at which this button is pressed has little influence over the time of pressure drop. The released fluid is caught in the collector sleeve (Fig. 1(g)) and drained into any suitable receptacle for reuse.

3. METHOD OF USE

With the piston fully retracted the reservoir and pressure chamber are filled with fluid. Experience has shown that before inserting the cable seal and clamp the fluid level needs to be about 50 mm from the top of the pressure chamber (this avoids trapping large amounts of air).

The assembly of the cable seal and clamp is shown in Fig. 3. The components (c), (l), (j) and (h) are thread over the transducer and cable in the order shown, the three jaws of the collet (b) are placed into the tapered end of the housing (j) each jaw locating on a pin projecting inside the housing.

The knurled nut (h) is screwed onto the housing (j) to retain the collet and lightly clamp the cable, the transducer projecting approx. 130 mm from the nut (Fig. 3(m)); there is no need for the nut (h) to be tightened excessively as the clamp becomes self-sealing and self-holding under pressure.

The half washers (k) and the split rubber washer (a), together with the sleeve (l), are pushed into the top end of the housing.

The complete clamp assembly is then inserted into the top of the pressure chamber displacing some of the fluid which will spill over; the retaining nut (c) needs only to be firmly screwed down.

/Air .....

Air trapped in the system can be excluded by screwing home the piston with the nut (c) slackened, air being forced passed the cable, retracting the piston with the nut (c) screwed down will draw fresh fluid from the reservoir.

With the transducer connected to the recording equipment and the test gauge closed off by shutting the isolating valve, screwing in the piston will bring the unit up to the pressure required, pressing the release button will drop the pressure to zero.

4. DESIGN OF PRESSURE RELEASE

The principle of operation of the release valve (Fig. 4) is as follows.

The trapped spring (a) is assembled preloaded and exerts force against the flange of the sleeve (b). The other end of the sleeve is drilled in four places and carries in each hole a steel ball (c). Each ball is also partly engaged in a groove cut in the valve rod (d). Escape of the steel balls in an outward direction is prevented by the outer sliding sleeve (e), hence, the spring force is exerted through the valve rod (d) and via the steel ball (f) to the cone tip (g). The cone tip (g) pressing against the screwed in seating (h) seals against the fluid pressure.

Due to the sliding action that the spring force induces between (b) and (d) an outward force is given to the steel balls (c). Sliding the sleeve (e) forward allows the steel balls to escape from the groove in (d). The sleeve (e) is then assisted forward by the escaping balls bearing against the chamfer cut on the inside of the sleeve.

To complete the action (b) moves forward and rests against the housing (j). The valve rod (d) becomes free and the fluid is able to push back the cone tip and escape.

The upper half of the lower drawing (Fig. 4) shows the released position with the valve rod, etc. about to be pushed back by the fluid.

The valve is snap action in opening and hence operates quickly.

The release button is screwed onto the end of the sleeve (e) and it was intended that rotating the release button would draw back the sleeve (e) against the spring pressure. In practice this has proved unneccessary the valve being reset easily by simply pulling back by hand.

5. CONCLUSIONS

One unit has been built and is in daily use giving satisfactory results.

For greater accuracy of establishing the pressure in the unit, the pressure gauge assembly could be replaced by a dead weight system.

The pressure release valve with a suitably designed spring could act also as a safety relief valve thus preventing overloading of the unit.

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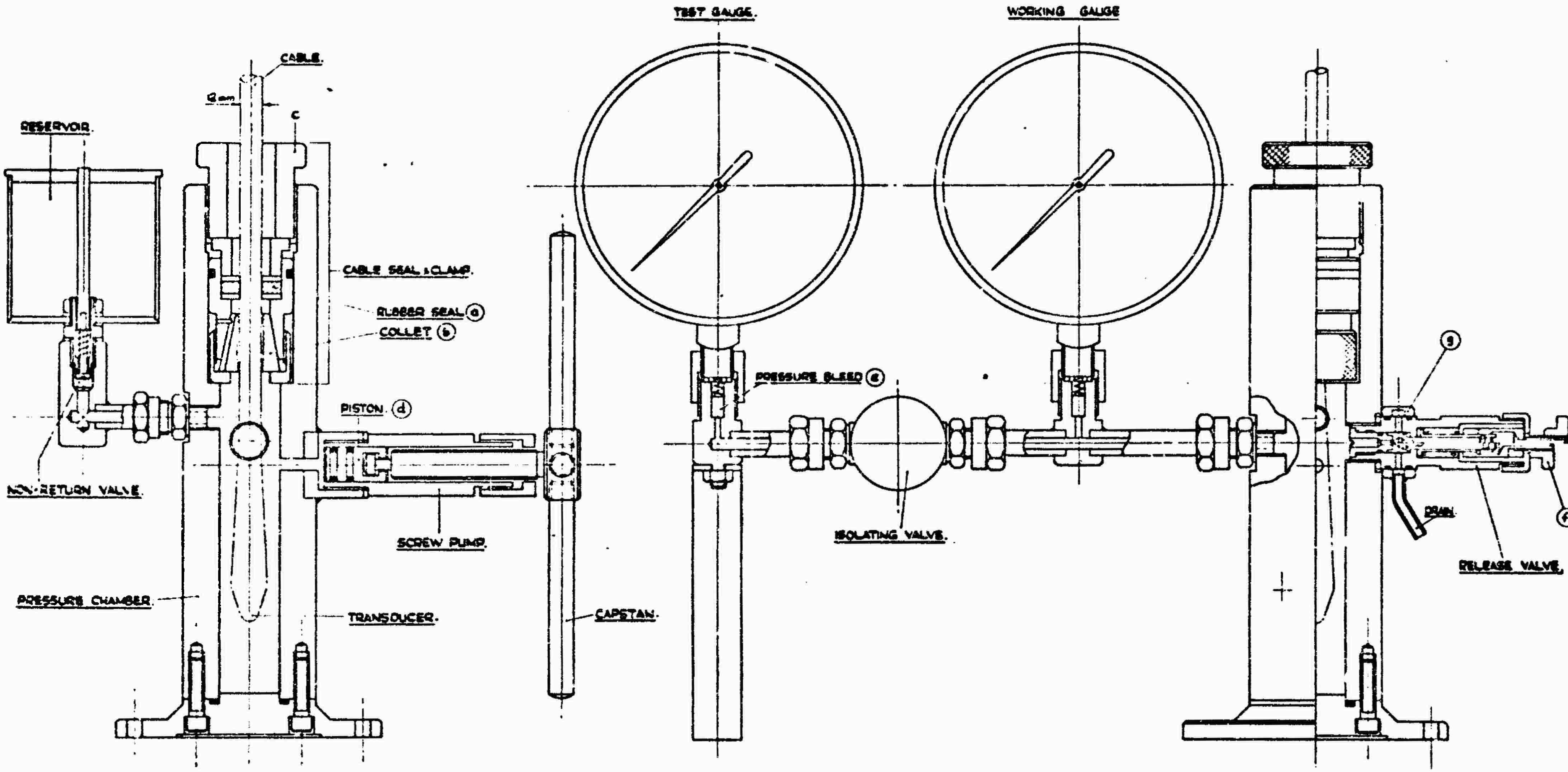
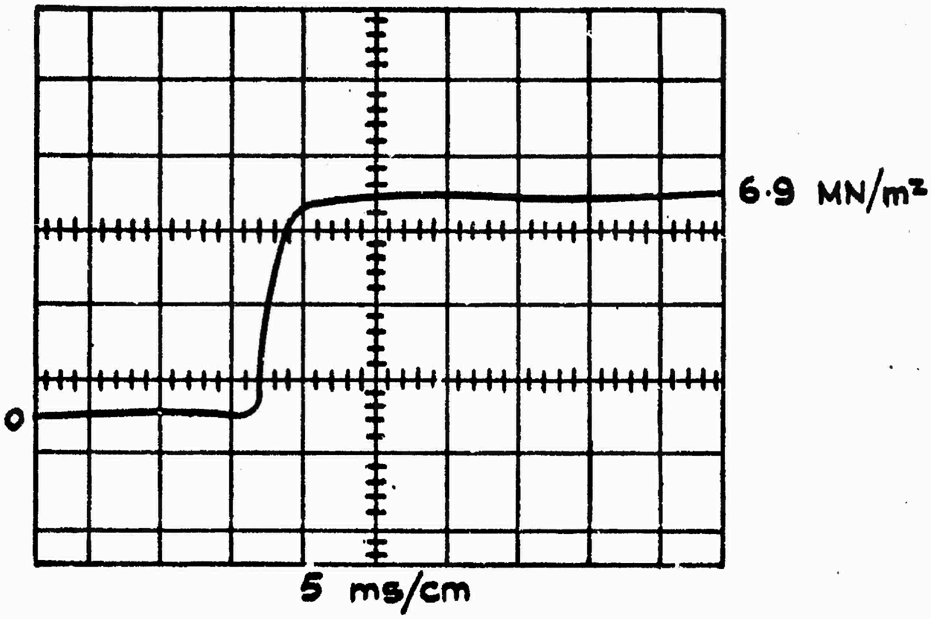


FIG. I HYDROSTATIC PRESSURE CHAMBER.



4a

FIG. 2 OSCILLOSCOPE TRACE - RELEASE TIME

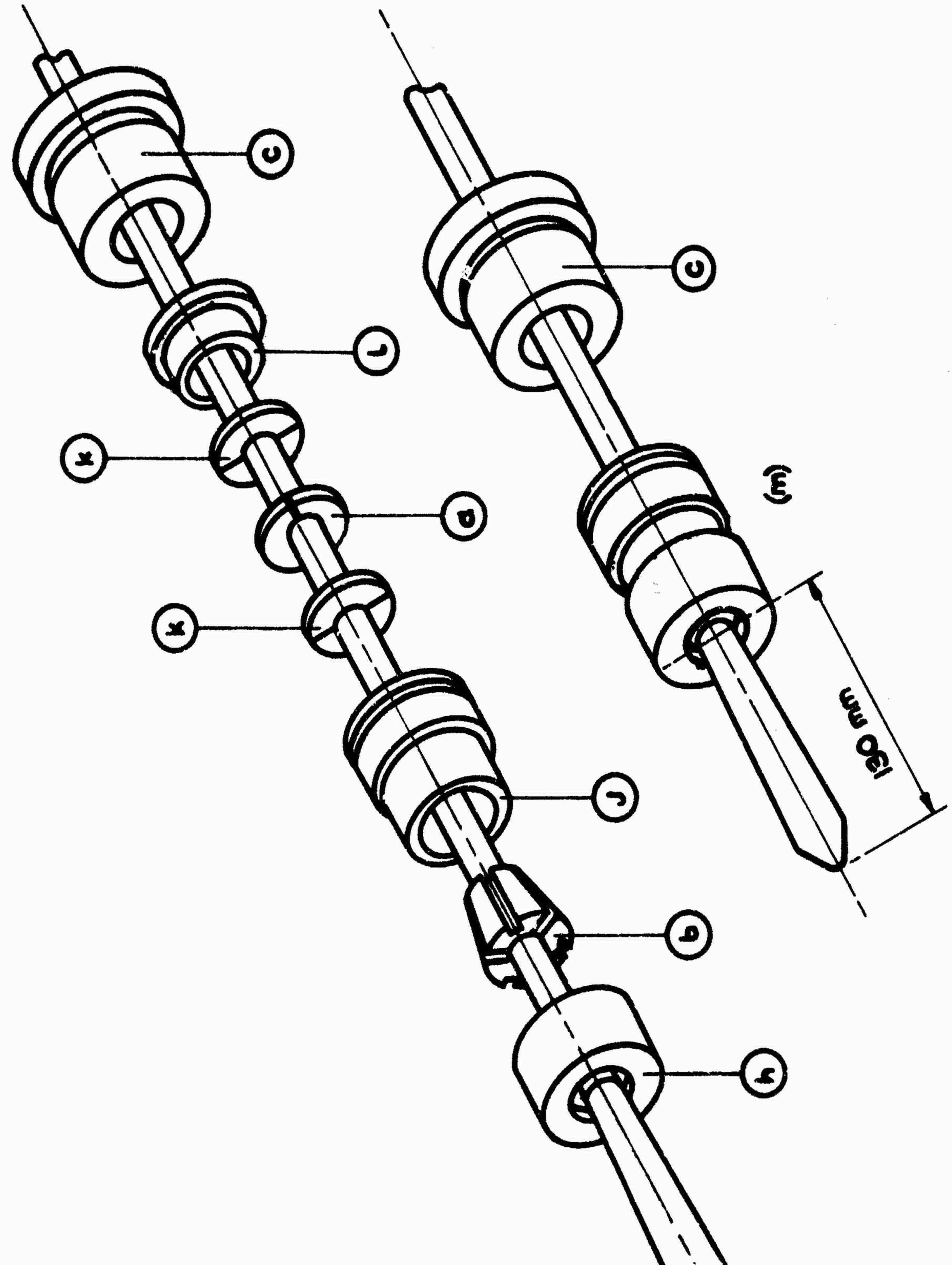


FIG. 9. CABLE SEAL AND CLAMP

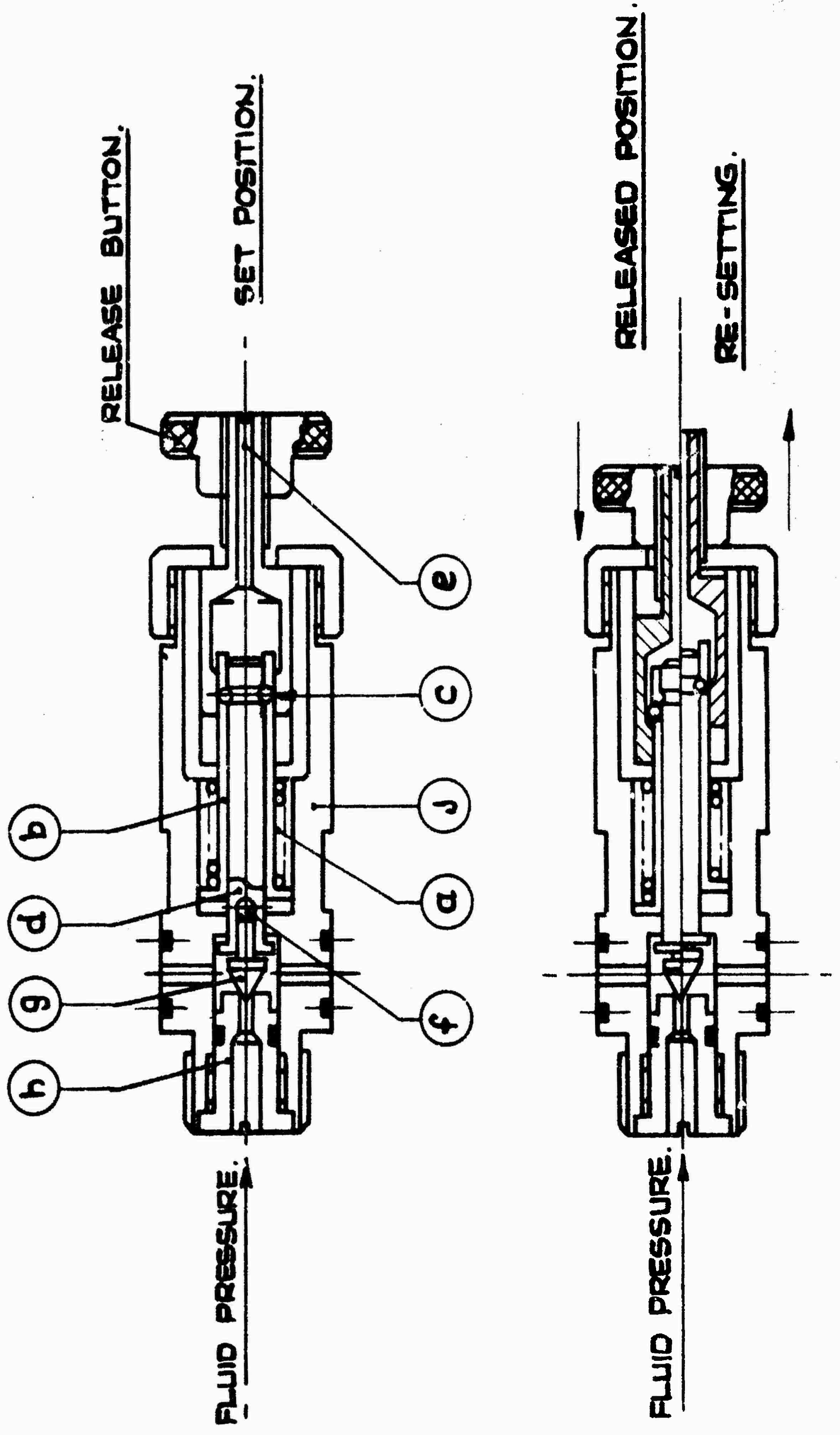


FIG 4 PRESSURE RELEASE VALVE.